FIG. 1

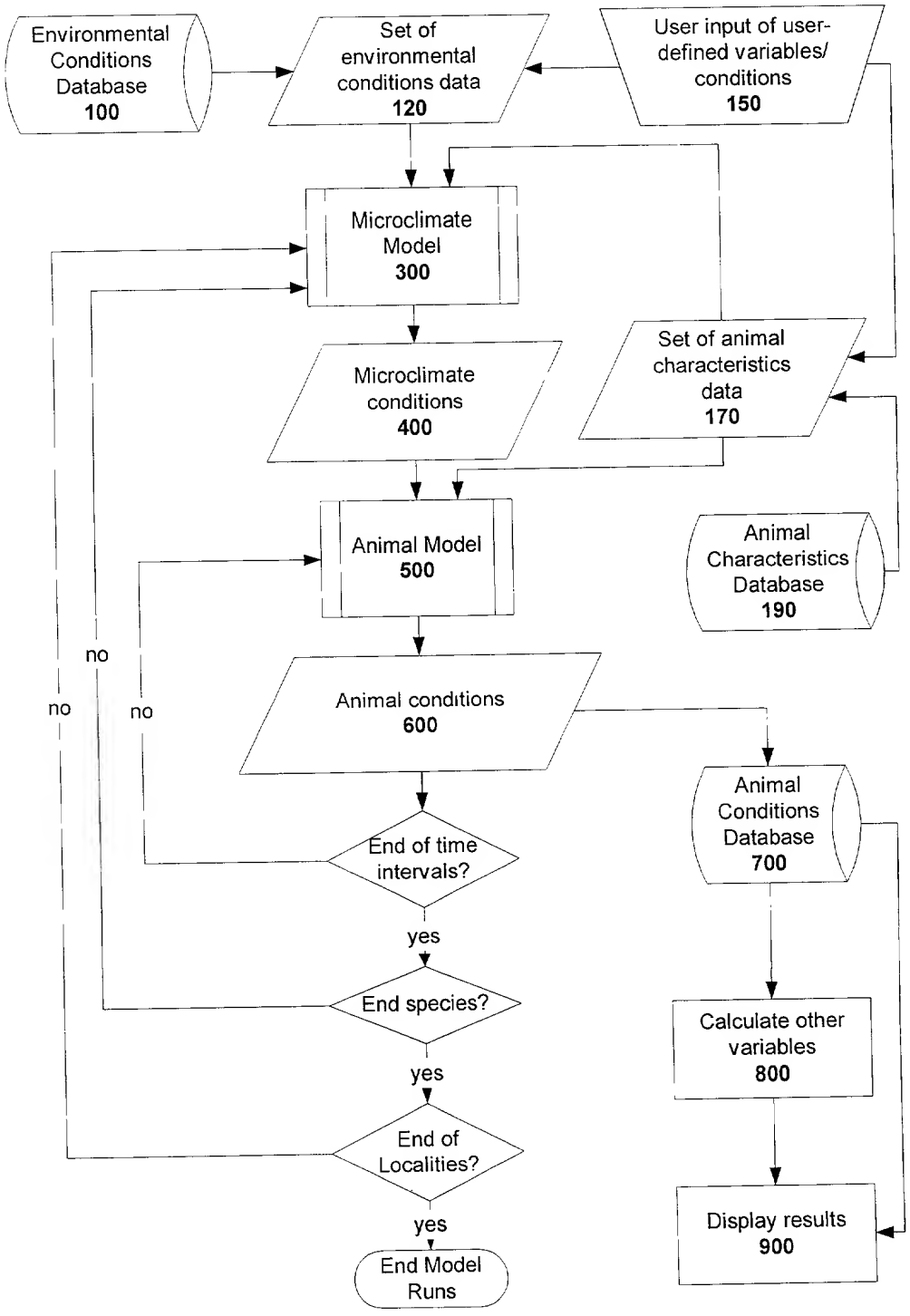
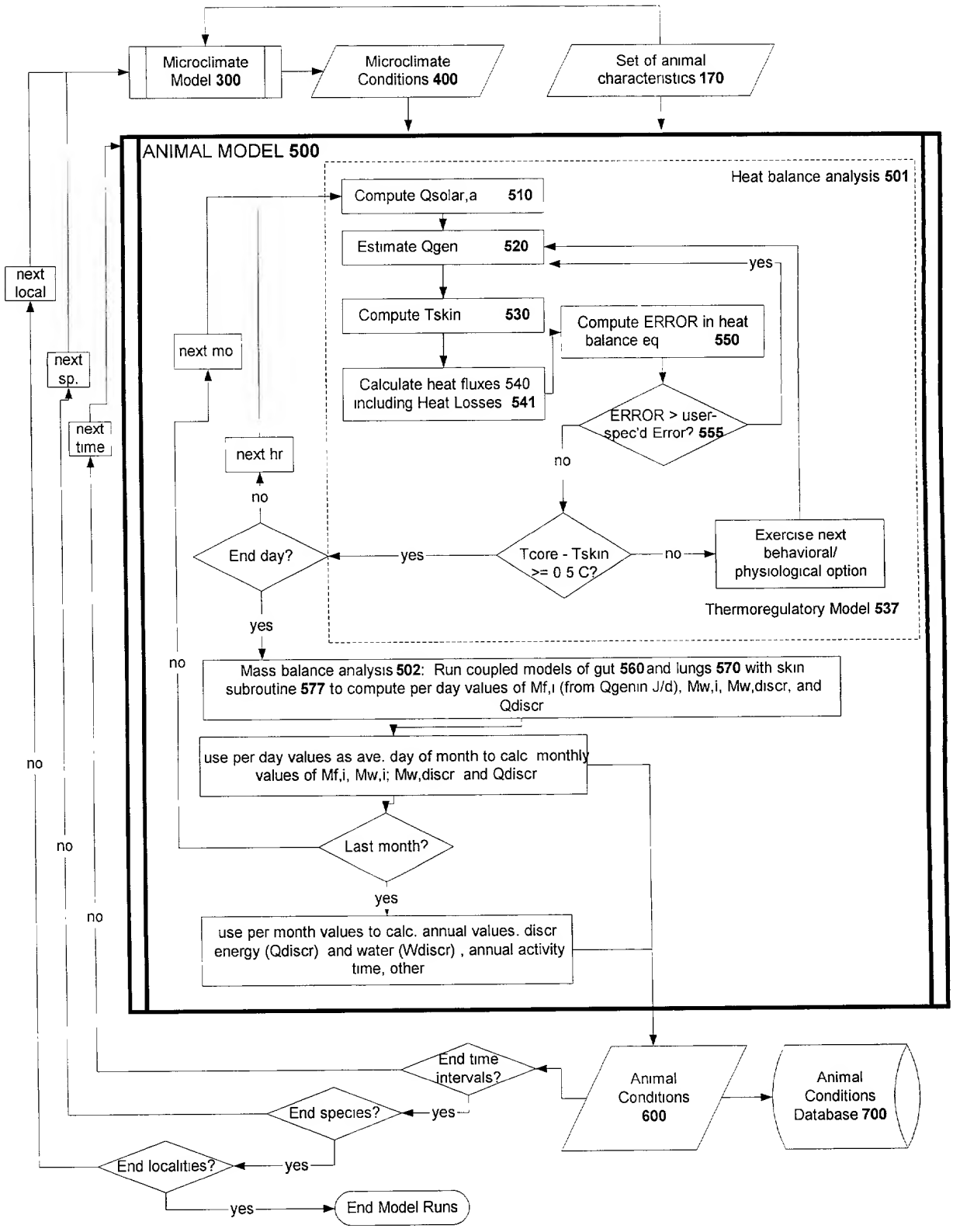

Environmental Conditions Database 100
Set of environmental conditions data 120
User input of user-defined variables/ conditions 150
Microclimate Model 300
Microclimate conditions 400
Set of animal characteristics data 170
Animal Model 500
Animal Characteristics Database 190
Animal conditions 600
Animal Conditions Database 700
End of time intervals?
yes
End species?
yes
End of Localities?
yes
End Model Runs
Calculate other variables 800
Display results 900
no
no
no

FIG. 2


Microclimate Model 300
Microclimate Conditions 400
Set of animal characteristics 170
ANIMAL MODEL 500
Heat balance analysis 501
Compute Qsolar,a 510
Estimate Qgen 520
Compute Tskin 530
Calculate heat fluxes 540 including Heat Losses 541
Compute ERROR in heat balance eq 550
ERROR > user-spec'd Error? 555
yes
no
Tcore - Tskin >= 0 5 C?
yes
no
Exercise next behavioral/ physiological option
Thermoregulatory Model 537
End day?
yes
no
next hr
next mo
next local
next sp.
next time
Mass balance analysis 502: Run coupled models of gut 560 and lungs 570 with skin subroutine 577 to compute per day values of Mf,i (from Qgenin J/d), Mw,i, Mw,discr, and Qdiscr
use per day values as ave. day of month to calc monthly values of Mf,i, Mw,i; Mw,discr and Qdiscr
Last month?
yes
no
use per month values to calc. annual values. discr energy (Qdiscr) and water (Wdiscr) , annual activity time, other
End time intervals?
End species?
End localities?
End Model Runs
Animal Conditions 600
Animal Conditions Database 700

FILED: 05 FEBRUARY 2009

FIG. 3a

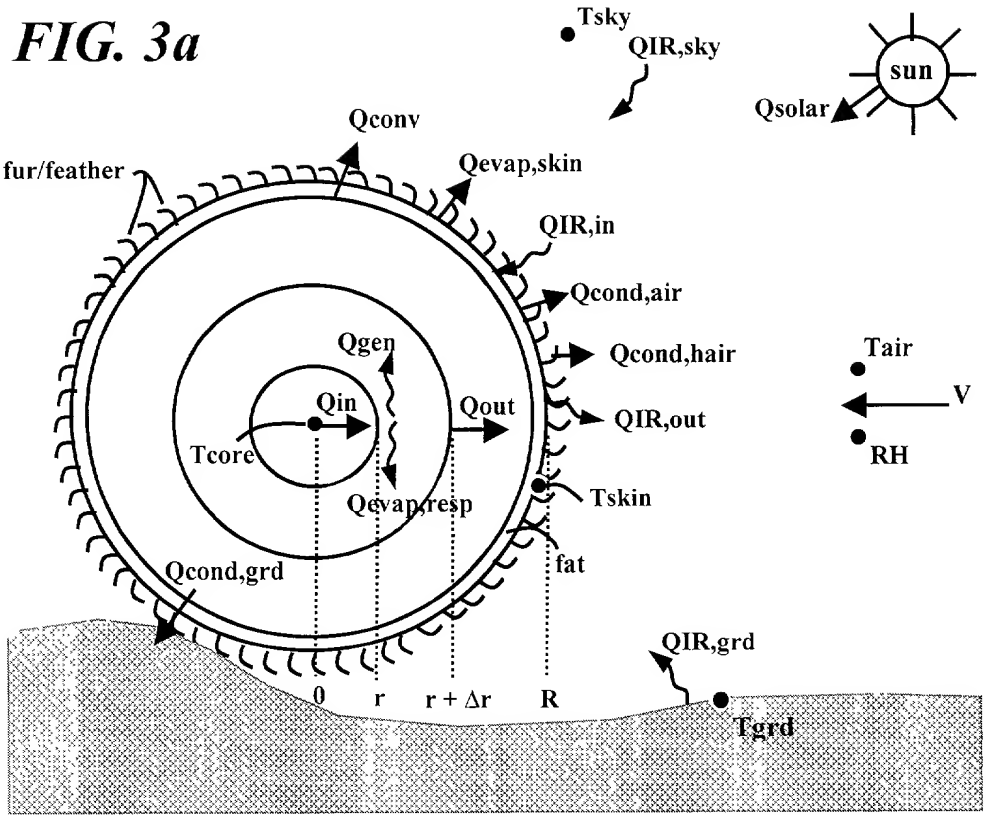
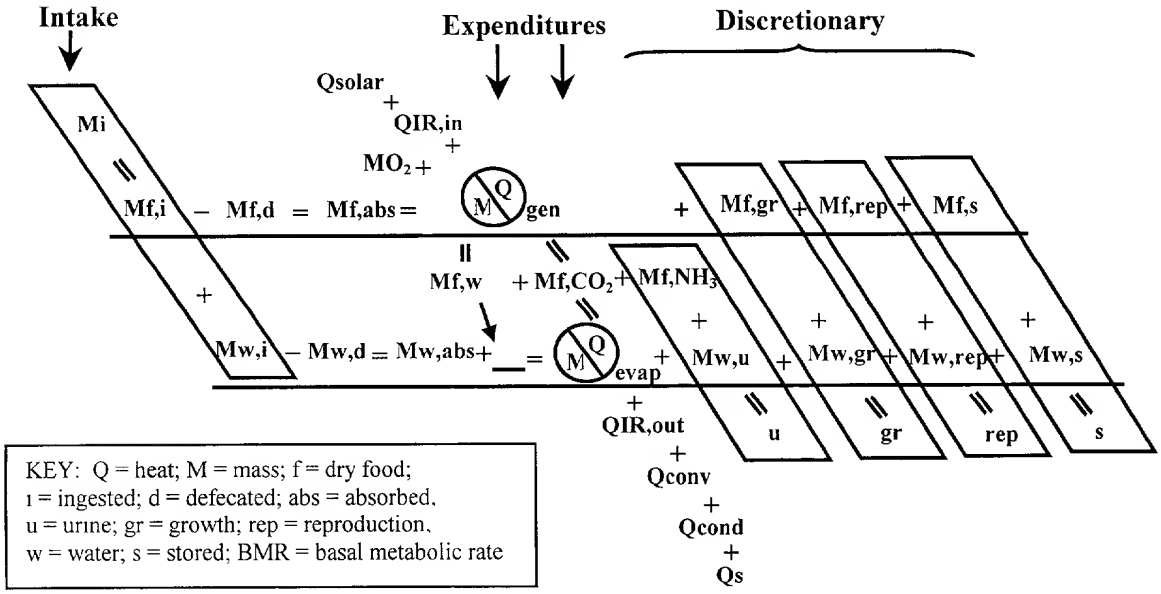


FIG. 3b



KEY: Q = heat; M = mass; f = dry food;
i = ingested; d = defecated; abs = absorbed,
u = urine; gr = growth; rep = reproduction,
w = water; s = stored; BMR = basal metabolic rate

$$\left(\frac{M}{Q}\right)_{gen} = \left(\frac{M}{Q}\right)_{BMR} + \left(\frac{M}{Q}\right)_{Activity} + \left(\frac{M}{Q}\right)_{Synthesis} + \left(\frac{M}{Q}\right)_{Specific\ Dynamic\ Action}$$

FIG 4

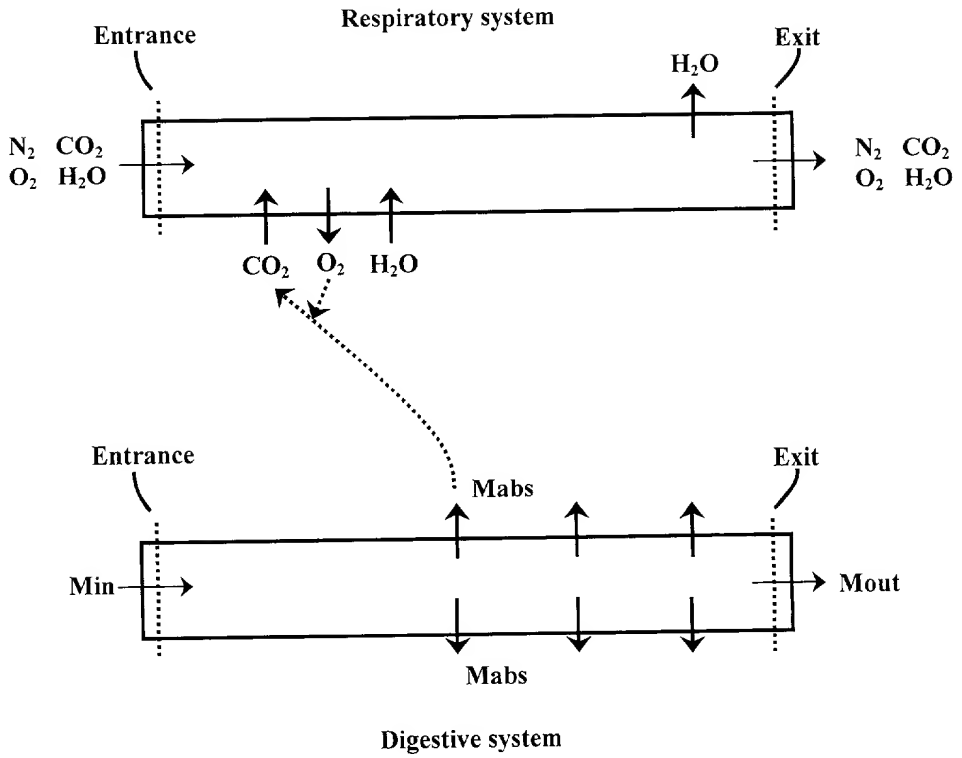

Respiratory system
Entrance
Exit
H_2O
N_2 CO_2
O_2 H_2O
N_2 CO_2
O_2 H_2O
CO_2 O_2 H_2O
Entrance
Exit
Mabs
Min
Mout
Mabs
Digestive system

FIG. 5a

VARIABLE	DEFINITION
abs	Absorbed (unless otherwise noted).
ABSAN	Animal absorptivity.
ABSSB	The absorptivity of the substrate.
ashade	Percent shade on the animal.
ASILN	Silhouette area normal to the sun.
B1ARA(1)	A variable that indicates the optical thickness of the fur or feathers; it is the exponent of Beer's Law (*i.e.* the extinction coefficient (τ)times the depth of fur/feathers (t)).
BETARA(2)	The IR extinction coefficient of fur/feathers.
BICV	A dimensionless variable for convection heat transfer.
BIR	A dimensionless variable for IR heat transfer.
C1N	Is C1 normalized; a dimensionless variable.
d	Defecated
D1	D1 is a dimensionless variable.
DigEff	Digestive efficiency.
dir	Direct.
discr	Discretionary.
EMIS	The emissivity of the animal.
evap	Evaporated.
f	Food (dry food).
Fa,grd	The configuration factor between the animal and the ground.
Fa,sky	The configuration factor between the animal and the sky.
Fabush	The configuration factor between the animal and the nearby object.
g	The heat generation per unit volume.
gfatpg, gprotpg, gcarbpg	The grams of fat, protein, and carbohydrate per gram dry mass of food .
gr	Growth.
grd	Ground or other surface.
gundig	Undigested mass per gram dry mass of food.

FIG. 5b

gw	Grams water.
HC	HC is the convection heat transfer coefficient.
hor	Horizontal to.
HR	HR is the radiant heat transfer coefficient.
i	Ingested.
IR	Infrared.
Jabspgr	Joules absorbed per gram of dry food.
K	Thermal conductivity for tissue.
KEFAR	KEFAR is the effective thermal conductivity of fibers and air for conduction.
KRADSKY/ GRD/BUSH	The fur/feather radiant conductivity in the sky/ground/bush direction.
M	Mass.
Mdiscr	Total discretionary mass; Mw,discr + Mf,discr.
met	Metabolism.
Mf,a	Mass of food absorbed.
Mf,d	Mass of food defecated.
Mf,discr	Total discretionary mass from food; Mf,gr + Mf,rep + Mf,s.
Mf,gr	Discretionary mass from food available for growth.
Mf,i	Mass of food ingested.
Mf,met	Mass of food metabolized.
Mf,rep	Discretionary mass from food available for reproduction.
Mf,s	Discretionary mass from food stored.
Mf,w	Mass of water in food absorbed (Mf,a).
Mw,a	Mass of water absorbed.
Mw,d	Mass of water defecated in feces.
Mw,discr	Total discretionary mass from water (Mw,gr + Mw,rep + Mw,s).
Mw,gr	Discretionary mass from water available for growth.
Mw,i	Mass of water ingested.
Mw,met	Mass of water metabolized.
Mw,rep	Discretionary mass from water available for reproduction.
Mw,s	Discretionary mass from water stored.
Mw,u	Mass of water excreted in urine.
n	Geometry constant (varies with shape).
norm	Normal to.

FIG. 5c

PCTDIF	Percent diffuse solar radiation.
pctfat, pctpro, pctcar	User specified percentages of these components of food – fat, protein, carbohydrates.
PSI	PSI is a correction factor.
Q	Heat.
Qcond	Conduction (via air and fur/feathers) from dorsal and ventral sides of animal.
Qcond,air	Conduction via the air.
Qcond,hair	Conduction via the fur/feathers.
Qconv	Convection at the fur-air interface.
Qdiscr	Discretionary energy available to the animal.
Qdorsl	Amount of energy absorbed on the top/dorsal parts of animal.
Qevap,resp	Energy loss by evaporation in respiration.
Qevap,skin	Energy loss by evaporation at skin.
Qfur	Energy flux via the fur/feathers.
Qgen	The metabolic heat generation needed to maintain the animal's core temperature.
Qin	the amount of heat entering the animal from external sources (Qsolar,a, QIR,in, QIR,sky, QIR,grd, other sources).
QIR,above	The IR fluxes from above the animal.
QIR,below	The IR fluxes from below the animal.
QIR,grd	IR fluxes from the ground (or other surface).
QIR,in	IR radiation emitted inward through the porous insulation.
QIR,out	IR radiation emitted outward from the fiber elements toward the sky
QIR,sky	IR fluxes from the sky.
QIR,veg	IR fluxes from vegetation.
Qmet	Uniform heat generation.
Qnet	Net heat exchange for the whole animal.
Qnorm	Total solar radiation incident on a surface normal to the sun's direct beam.
Qout	the amount of heat leaving the animal to the environment .
QRADSK/ GRD/BUSH	The incoming solar IR radiation from the sky/ground/bush through the porous media.
Qresp	Uniform heat dissipation by respiration.
QSDIFF	The total amount of diffuse solar radiation.

FIG. 5d

QSOBJ	Incoming diffuse radiation reflected by an object nearby.
Qsolar	Clear sky solar radiation.
Qsolar,a	Amount of solar radiation (watts) absorbed by the animal.
Qsolar,dir	Direct beam solar radiation.
Qsolar,hor	The incoming solar radiation on a horizontal surface.
QSRSB	The incoming solar radiation reflected from the substrate (*i.e.* ground or other substrate).
QSSKY	The diffuse solar radiation from the sky (*i.e.* solar radiation scattered by molecules in the atmosphere and by clouds).
Qventr	Amount of energy absorbed on the bottom/ventral parts of animal.
R	Radius of animal.
Rep	Reproduction.
resp	Respiration.
RH	Relative humidity of air passing over the animal at its average height above ground.
RQ	Respiratory quotient..
S	Stored.
sig	The Stefan-Boltzmann constant.
Tair	Air temperature at animal's average height.
Tair,2m	Temperature of air at 2 m height.
TAVsky/grd/ bush	Sky/ground/bush portions of radiant heat exchange (degrees K).
Tgrd	Ground/surface temperature.
Tgrd(i)	The ground temperature at location (i).
Timbas	Basal multiplier (*i.e.* activity above resting).
TK	Temperature at degrees Kelvin.
TKair,TKskin, TKsky, TKbush	The temperatures of air, skin, sky, bush, respectively, in degrees K.
TOTCARB	Total carbohydrates.
TotJpgram	Joules per gram dry food.
Tskin	The skin temperature of the animal.
Tsky	Clear sky radiant temperature.
Tveg	Temperature of vegetation (or other objects) overhead of the animal.
U	Urine.
V	Velocity of air passing over the animal at its average height above ground.
w	Water.
Mw,evap	Mass of water lost by evaporation (Mw,evap,resp + Mw,evap,skin).
Mw,evap,resp	Water loss by evaporation in respiration.
Mw,evap,skin	Water loss by evaporation at skin.
ZFURAR	ZFURAR is the depth of fur.

FIG. 6

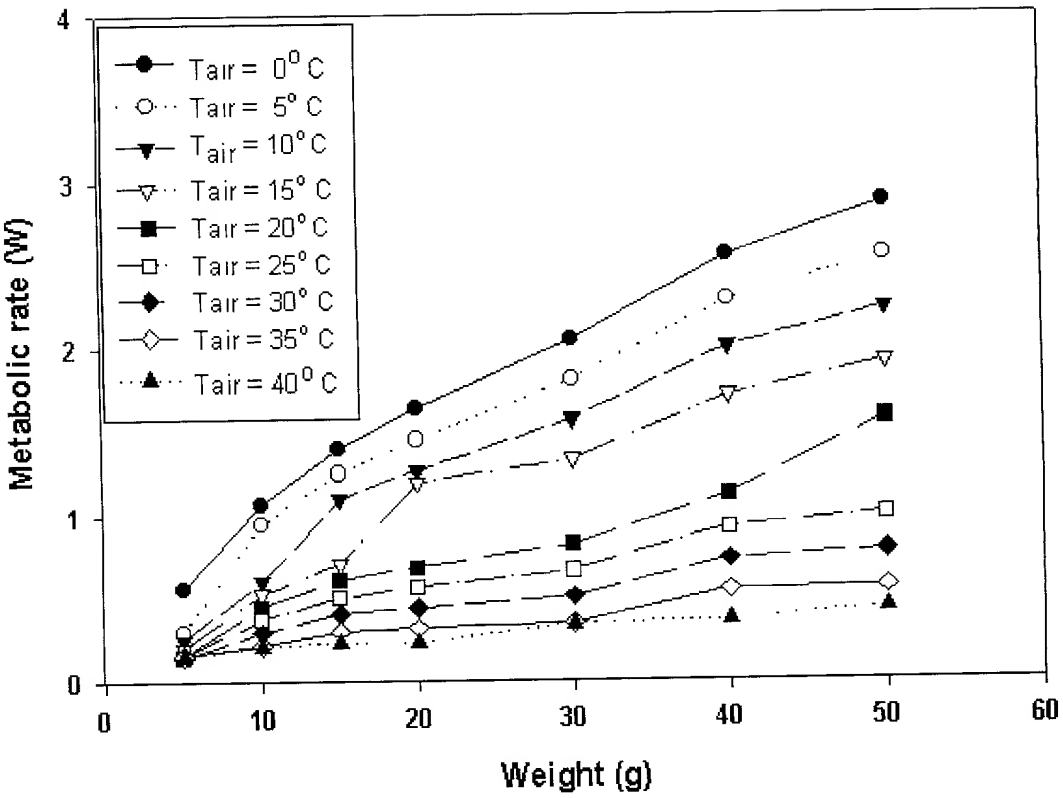
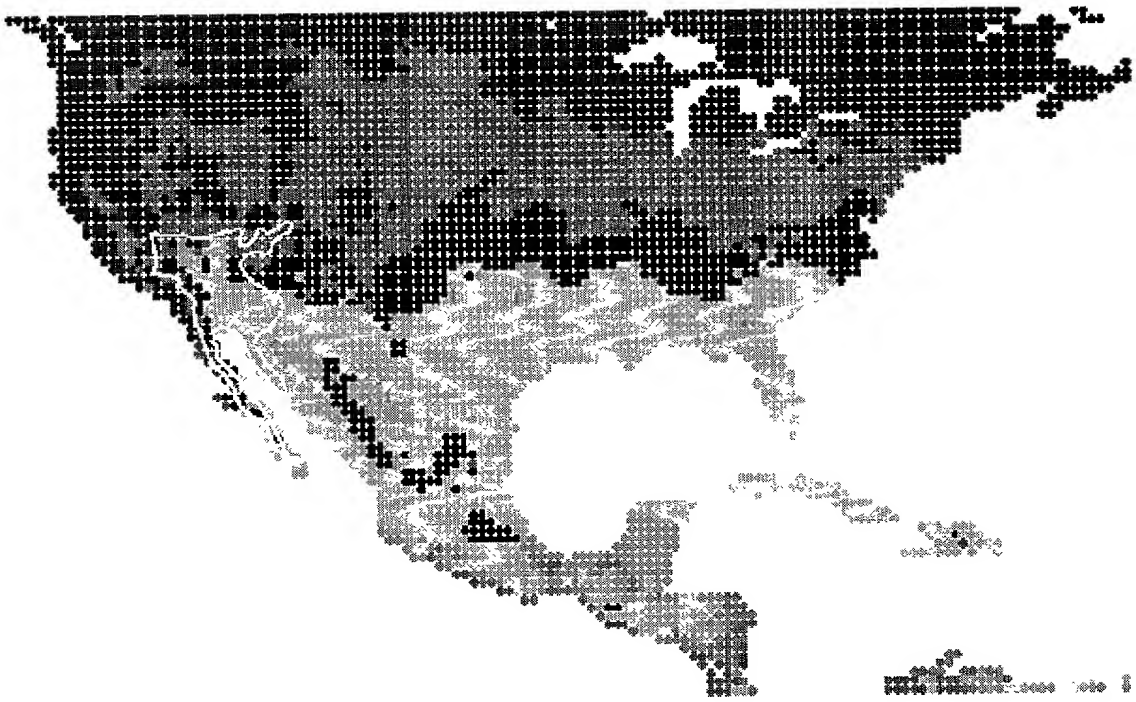

Tair = 0° C
Tair = 5° C
Tair = 10° C
Tair = 15° C
Tair = 20° C
Tair = 25° C
Tair = 30° C
Tair = 35° C
Tair = 40° C
Metabolic rate (W)
Weight (g)
0
1
2
3
4
0
10
20
30
40
50
60

FIG. 7



Degree days at 10 cm depth:

- 0 – 852
- 852 – 1704
- 1705 – 2556
- 2557 – 3408
- 3409 – 4260
- 4261 – 5112
- 5113 – 5964
- 5965 – 6816
- 6817 – 7668
- 7669 - 8520

FIG. 8

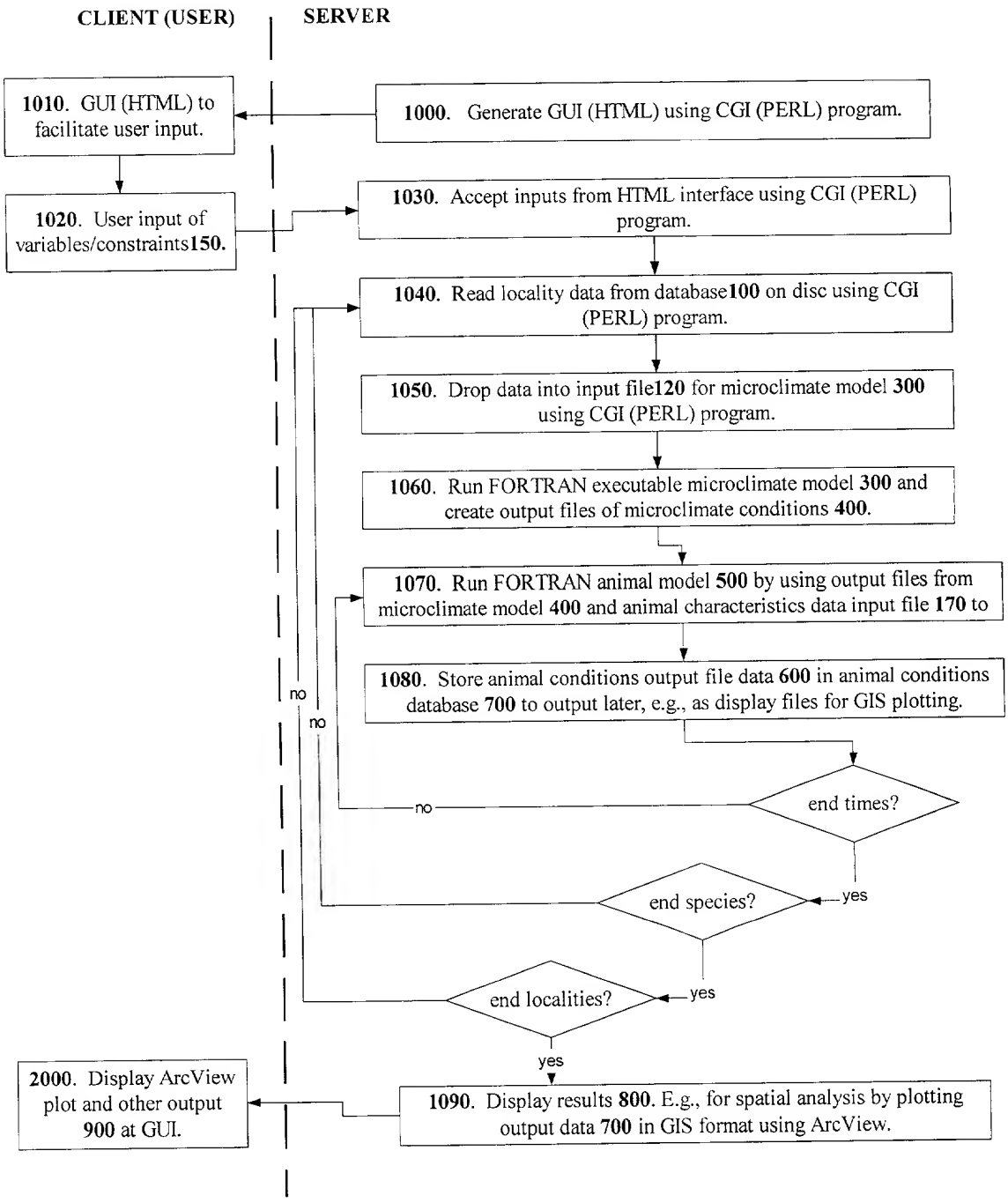
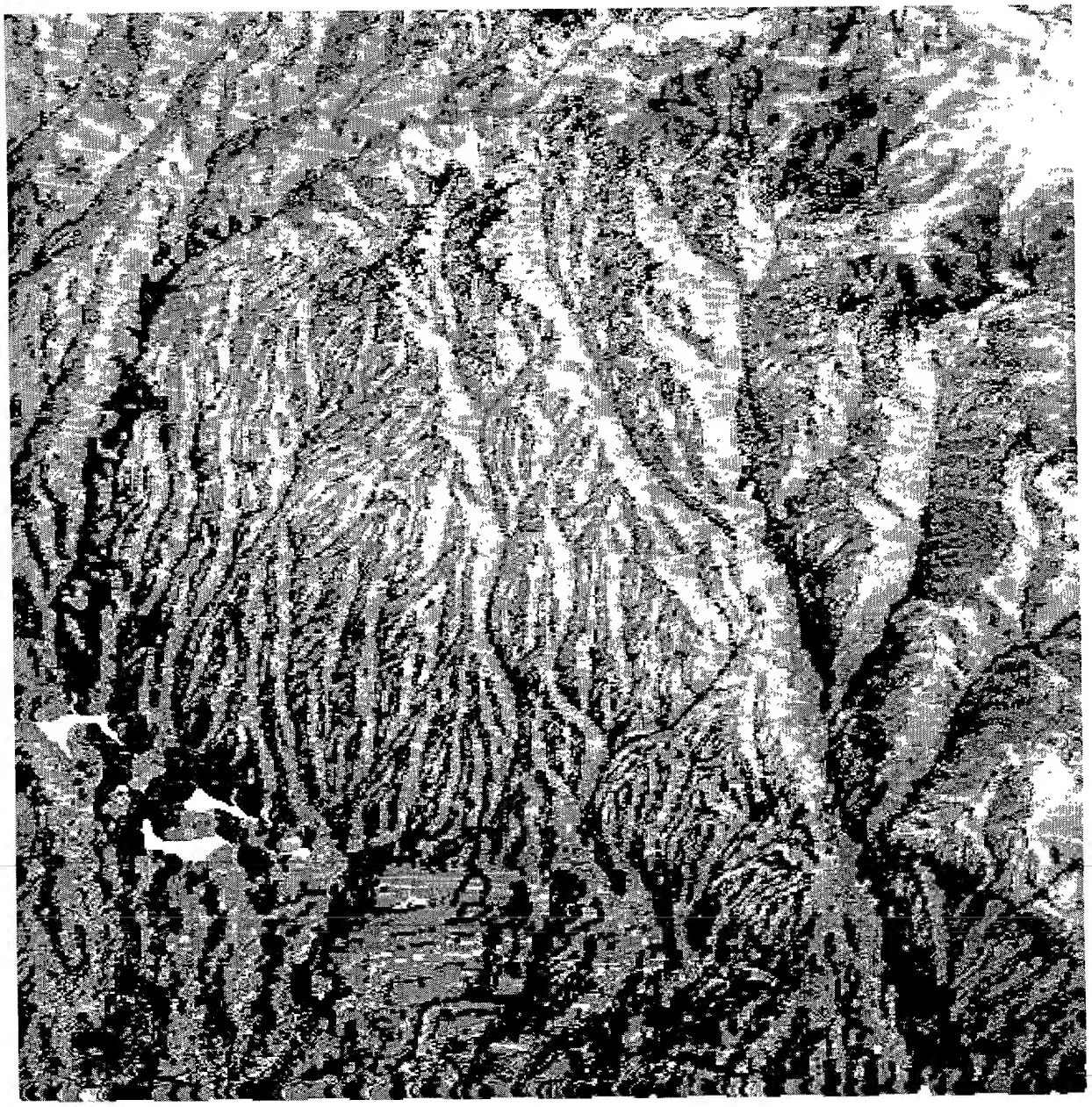

CLIENT (USER)
SERVER
1010. GUI (HTML) to facilitate user input.
1000. Generate GUI (HTML) using CGI (PERL) program.
1020. User input of variables/constraints150.
1030. Accept inputs from HTML interface using CGI (PERL) program.
1040. Read locality data from database100 on disc using CGI (PERL) program.
1050. Drop data into input file120 for microclimate model 300 using CGI (PERL) program.
1060. Run FORTRAN executable microclimate model 300 and create output files of microclimate conditions 400.
1070. Run FORTRAN animal model 500 by using output files from microclimate model 400 and animal characteristics data input file 170 to
1080. Store animal conditions output file data 600 in animal conditions database 700 to output later, e.g., as display files for GIS plotting.
end times?
no
end species?
yes
no
end localities?
yes
no
yes
2000. Display ArcView plot and other output 900 at GUI.
1090. Display results 800. E.g., for spatial analysis by plotting output data 700 in GIS format using ArcView.

FIG. 9



Discretionary energy in July as a function of slope and aspect of topography for Mountain Lion (kJ/d)

13298 -18751
11755 - 13298
11165 - 11755
10644 - 11165
9736 - 10644

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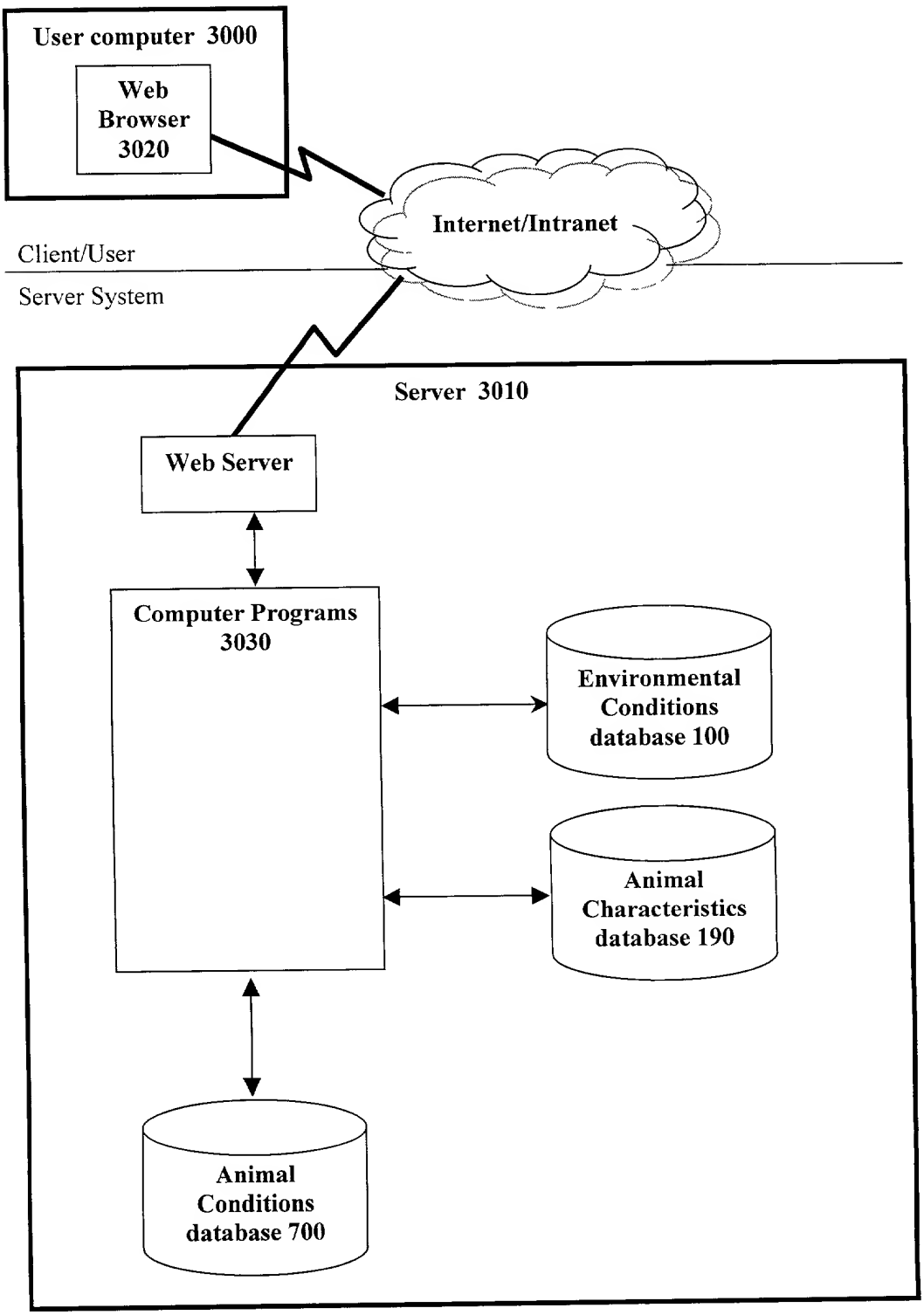
FIG. 10


User computer 3000
Web Browser 3020
Internet/Intranet
Client/User
Server System
Server 3010
Web Server
Computer Programs 3030
Environmental Conditions database 100
Animal Characteristics database 190
Animal Conditions database 700